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UNITED STATES PATENT APPLICATION

FOR

CABLE APPARATUS FOR MINIMIZING SKEW DELAY OF ANALOG SIGNALS AND CROSS-TALK FROM DIGITAL SIGNALS, AND METHOD OF MAKING SAME

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BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of electronic cable equipment, and more specifically, to cables used for the concurrent transmission of analog and digital signals, such as for analog video and digital audio.

2. Background Art

Data networks, or LANs, typically use low cost UTP (unshielded twisted pair) wire for bi-directional communication of digital data. In addition, special application of UTP may be used to convey analog video signals over a dedicated video-type network. In both cases, the current constructions of UTP wherein four twisted pairs are utilized, involve manipulation of the twisted pairs such that each pair has a different lay length throughout the cable so as to minimize cross-talk of data signals between pairs. Various lay lengths are combined such that coupling is minimized. One configuration describes a UTP cable having two of the typically four pairs twisted in a right-hand direction while the remaining two pairs are twisted in the usual left-hand direction. This combination further minimizes cross coupling for data signals traveling on the cable pairs.

Figures 1A and 1B illustrate the construction of a prior art Unshielded Twisted Pair (UTP) cable for data transmission. As illustrated in Figure 1A, a typical UTP cable 100 comprises four twisted pair wires 104, 106, 108, and 110, all located within a cable

bundle. The bundled twisted pair wires are held together with insulation layer 102. Referring to Figure 1B, each of the four twisted pairs (e.g. 104, 106, 108 or 110) consists of two wires identified with suffix "A" and "B" and having a specific lay length. For instance, twisted pair 104 comprises wire 104A and wire 104B having a constant lay length "A" throughout its length; twisted pair 106 comprises wire 106A and wire 106B having a constant lay length "B" throughout its length; twisted pair 108 comprises wire 108A and wire 108B having a constant lay length "C" throughout its length; and twisted pair 110 comprises wire 110A and wire 110B having a constant lay length "D" throughout its length.

As illustrated, each of the prior art twisted pair cables (e.g. 104, 106, 108, or 110) has a specific lay length different from the other twisted pairs. All of these twisted pairs, each one made with a specific lay length, are located side-by-side within a cable bundle. The different lay lengths contribute to reduced cross-talk.

In the application of analog video, including RGB analog video or graphics, UTP data cables may be utilized. Implementations suffer from the fact that the data cable construction having different lay lengths between conducting pairs results in each pair having a different electrical length. The differing electrical lengths result in proportional delay of the video signal when applied over the long distances (around 100 meters or more) typically encountered in this type of application.

The different electrical lengths result in a relative delay between RGB signals in an RGB analog video implementation, for example. The delay period is long enough to create an offset of visual information on the display screen so as to appear misconverged. Graphics details will not properly line up on the screen at the appropriate location. This "fringing effect" makes for poor quality or totally unacceptable video performance. To counteract this affect, some form of delay must be added to the shorter pathways in the transmission line to equalize the delays such that the longest delay becomes the standard by which the others are adjusted. Various methodologies for accomplishing this are known. For example, an appropriate length of cable may be added to each of the faster transmission lines to compensate. In addition, various electrical circuit schemes exist for delaying video channels within the processing system that receives the UTP-transmitted information and converts it to usable analog content.

The above scenario describes results based on use of three of the four available twisted pairs within the bundle. The three active pairs are conveying red, green, and blue signals respectively. The fourth pair of the bundle may or may not be used. In cases where the fourth pair is used, it may carry digital control and/or audio channels. The intimacy of this fourth pair with the other three carrying video information can cause significant signal coupling, or cross-talk, wherein the digital signal induces noise into any or all of the three video-carrying pairs.

Extron recognized a need to correct for these problems by manufacturing a low-skew UTP cable. In the low-skew cable, the lay lengths of the twisted pairs are equal in

length. Equal lay lengths on the pairs mean that the electrical lengths are very nearly equal. The time difference becomes so small that it is, for all practical purposes, negligible. Furthermore, the twisted pairs are bundled together utilizing the standard twist-lay process used for such a cable. This is a departure for UTP-type data networks because the equal length pairs will promote close coupling of digital data and not be suitable for data networks.

In analog video and graphics application, the cross coupling is not a prime issue. The cross coupling is small enough that the receiver can be equalized to mostly ignore it since the analog video system is a one-way transmission application. However, when digital control signals and/or digital audio channels are conveyed over the fourth pair in these applications, noise is often induced into one or more of the video-carrying pairs. Additionally, the signaling voltage on the typical analog RGB or video system is not compliant with voltages used for data networks. This means that UTP cabling that might be used for data networks must be wholly dedicated to the analog video application and cannot be shared. Applying the typical analog video connection to a UTP within a data network will not only be format incompatible, it will likely damage network components.

Utilization of the low-skew UTP cable is appropriate for dedicated installations where prior knowledge of the analog video/graphics system is prescribed. Clearly, this cable will be dedicated to the analog "network" and not used for data. Likewise, the data network could use the cable but will likely not use it because key cross-talk parameters

important to data network communications will be severely compromised such that the data network node may not perform at all.

Therefore, there is a need for a cable that can satisfy the low skew requirements of video signaling, while providing sufficient cross-talk isolation so that digital information simultaneously conveyed through the cable does not significantly impair the quality of the video signals.

SUMMARY OF THE INVENTION

The present invention provides a cable apparatus for minimizing skew delay of analog signals and cross-talk from digital signals, and method of making same. In an embodiment of the invention, the cable comprises multiple unshielded twisted pairs (UTP) of conductors that accommodate the transmission of multiple analog signals, such as for analog video, and one or more digital signals, such as for digital control and/or audio. The twisted pairs used to transmit analog signals may be of substantially uniform electrical length to minimize skew, and may also be twisted in the same lay direction (i.e., clock-wise or counter-clockwise).

To minimize cross-talk between the pair(s) carrying digital signal(s) and the pairs carrying analog signals, the twisted pair or pairs used to transmit digital signals may be twisted in the opposite lay direction with respect to the analog pairs, and may have a lay length that differs from any lay length used in the twisting of the analog pairs. In embodiments providing multiple pairs for digital transmission, the lay lengths and the lay directions of those pairs may also differ from one another.

In one embodiment, the twisted pairs for transmitting analog signals may be bound together as a group, and the pair or pairs for transmitting digital signals may be laid alongside the bundled pairs when the outer insulator jacket is applied to the cable. A UTP cable having the typical four twisted pair couplets may be constructed wherein three

of the pairs may be constructed with the same lay length and lay direction, while the fourth pair may be constructed with a different lay length and opposite lay direction.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A and 1B show a typical example of a UTP cable of the prior art.

Figure 2 is a cross-sectional view of a UTP cable in accordance with an embodiment of the invention.

Figure 3 is a cut-away view of a UTP cable in accordance with an embodiment of the invention.

Figure 4A and 4B are flattened views of a four-pair UTP cable in accordance with embodiments of the invention.

Figure 5 is a flow diagram of a process for making a UTP cable in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

A cable apparatus for minimizing skew delay of analog signals and cross-talk from digital signals, and method of making same are described. In the following description, numerous specific details are set forth to provide a more thorough description of the present invention. It will be apparent, however, to one skilled in the art, that the present invention may be practiced without these specific details. In other instances, well known features have not been described in detail so as not to obscure the present invention.

Embodiments of the invention may be constructed in a manner that provides for a group of twisted pairs having the group characteristic of low skew, while one or more further twisted pairs have the characteristic of reduced cross-talk with respect to the first group of twisted pairs and each other. For purposes of example, an embodiment suited to analog video applications will be described. Specifically, in this embodiment, a group of three twisted pairs of conductors is constructed with minimal skew for the purposes of transmitting three analog color video channels, e.g., a red (R) channel, a green (G) channel and a blue (B) channel. A fourth twisted pair of conductors is constructed to provide reduced cross-talk. This fourth pair may be used in the video application for the transmission of a digital (or analog) audio signal or a digital control signal, for example.

The structural features and method of construction associated with this four-pair embodiment may be similarly applied in other embodiments having more or fewer pairs with minimal skew, as well as more pairs with minimized cross-talk.

Figure 2 is a cross-sectional view of a UTP cable in accordance with an embodiment of the invention. The UTP cable comprises twisted pairs 201-204 surrounded by an outer protective jacket or sleeve 200. Each twisted pair contains a pair of wires (e.g., 201A and 201B), each of which comprises an inner conductor core 206 in an insulating sleeve 205.

Inner conductor 206 may be formed of, for example, of copper or some other conducting material. Insulation 205 may be formed of, for example, polyolefin or some other flexible material with insulating properties. The insulation 205 may be color coded or otherwise marked to identify respective pairs and individual wires within each pair. The outer jacket may be formed of, for example, extruded PVC (polyvinyl chloride) material.

In Figure 2, the dashed circles around each twisted pair represent the cross-sectional area occupied within the cable by the twisting of each pair. Dashed circle 207 represents the bundled pairs 201-203, occupying a circular cross-sectional area within the cable due to the twist bundling of pairs 201, 202 and 203. Twisted pair 204 occupies a cross-sectional area of the cable outside of the perimeter associated with bundle 207, giving the overall cable cross-section a "tear drop" shape.

Figure 3 is a cut-away view of a UTP cable constructed in accordance with an embodiment of the invention. In Figure 3, the different lay (or twist) directions within the UTP cable are made apparent. In the illustrated embodiment, twisted pairs 201, 202

and 203 are individually twisted in a first lay direction (i.e., clockwise). Twisted pairs 201-203 are then twisted together as a bundle (207), similarly in the first lay direction (clockwise).

Twisted pair 204 is not twisted within bundle 207, but is rather laid in parallel with bundle 207. Further, twisted pair 204 is twisted in the opposite lay direction (i.e., counterclockwise). While Figure 3 is not drawn to scale, the lay length of twisted pair 204 can be seen to be longer (i.e., has a lower twist rate) than the common lay length of twisted pairs 201-203. The differences in lay length are more clearly illustrated in Figures 4A and 4B.

Figure 4A is a flattened representation of the twisted pairs in accordance with one embodiment of the invention. In this embodiment, twisted pairs 401, 402 and 403 have the same lay length 405 and the same lay direction (represented by the arrows pointing to the right). Although twisted pairs 401, 402 and 403 are shown here with the same twisting phase (i.e., the twist "peaks" line up with each other), such an alignment is not required.

Twisted pair 404 is illustrated at some distance away from twisted pairs 401-403 to represent the fact that twisted pair 404 is not intimately bundled within the group including twisted pairs 401-403. Twisted pair 404 is illustrated with lay length 406 that is noticeably longer (i.e., has a lower twist rate) than that of twisted pairs 401-403 (i.e.,

lay length 405). Also, the lay direction (represented by the arrow pointing to the left) of twisted pair 404 is preferably opposite to that of twisted pairs 401-403.

Figure 4B illustrates an application of twist rates in accordance with an embodiment of the invention, in which twisted pairs 401-403 use multiple lay lengths, while maintaining substantially equivalent electrical lengths. As shown, during subinterval 407A, twisted pair 401 has lay length A, twisted pair 402 has lay length B, and twisted pair 403 has lay length C. During subinterval 407B, twisted pair 401 has lay length B, twisted pair 402 has lay length C, and twisted pair 403 has lay length A. During subinterval 407C, twisted pair 401 has lay length C, twisted pair 402 has lay length A, and twisted pair 403 has lay length B. Subinterval 408A repeats the lay length assignment of subinterval 407A, and so on. Twisted pair 404 is illustrated with lay length 406 throughout, which is preferably different than any of lay lengths A, B or C. (In embodiments with multiple additional pairs like twisted pair 404, those additional pairs may also implement a staggered or varying lay length arrangement.)

The electrical lengths of twisted pairs 401, 402 and 403 are unequal during any of the single distance subintervals illustrated (e.g., 407A, 407B, etc.) due to the different lay lengths implemented for each pair. However, over the complete distance interval 407, the lay length assignments complete a cycle in which each pair has applied each lay length for an approximately equivalent distance, thus providing equivalent electrical lengths over the complete interval.

The use of staggered lay length assignments in this embodiment improves cross-talk rejection between twisted pairs 401, 402 and 403. Further, by cutting the resulting cable into segments approximately equal to distance interval 407 or integer multiples thereof, the cable segments will have substantially equivalent electrical lengths within the group including pairs 401-403, satisfying the objective of minimized skew.

Figure 5 is a flow diagram of a process for constructing a UTP cable, in accordance with one embodiment of the invention. In block 500, a group of twisted-pair conductors are obtained with substantially equivalent electrical lengths. For the purposes of this description, substantial equivalence in electrical length means that the maximum difference in electrical length between any two twisted pairs is within a specified tolerance range. This specified tolerance range may vary for different applications, depending on the level of signal synchronization needed. For example, the tolerance range in a standard color video application might be at or around 0.5 inches in one embodiment.

The twisted pairs in this group may have a uniform lay length, or they may use a staggered arrangement of different lay lengths, as long as the overall electrical length within the group is uniform. This uniformity of electrical length provides the minimized skew characteristic desired in, for example, analog video applications. Preferably, the lay direction is the same for each twisted pair in the group.

In block 501, the twisted pairs may be twist-bundled together as a group, preferably, though not necessarily, with a bundled twist in the same lay direction as the individual pairs. This bundling helps to strengthen the cable, simplify the final jacketing process, and further enhance cross-talk rejection with respect to pairs that are not intimately bundled with the group.

In block 502, one or more additional twisted pairs are obtained that have a different lay length than the individual pairs in the bundled group. Preferably, the lay length(s) of the additional twisted pairs are longer than, and not an integer multiple of, the lay length(s) within the bundled group. For multiple additional pairs, their respective lay lengths may also differ from one another, at least in adjoining sections. For greater cross-talk rejection with respect to the bundled group of pairs, the additional pair(s) may have a lay direction that is opposite to that of the pairs in the bundled group.

In block 503, the outer insulator jacket is applied, with the additional pair(s) fed parallel to the bundled group during jacket extrusion. The result is a UTP cable having a group of pairs with minimal skew between them and significant cross-talk rejection with respect to one or more additional pairs. For a 3-and-1 UTP cable embodiment (i.e., three pairs in the bundle with one additional pair alongside), the resulting cross-section may be somewhat "tear drop" shaped.

In embodiments where the pairs in the bundled group have staggered sections of differing lay lengths, uniformity of the electrical lengths in the group may be optimized at

intervals along the cable (e.g., where the staggered lay-length pattern repeats). In some embodiments, those intervals may be marked on the outside of the cable jacket to facilitate cutting lengths of cable that will provide optimum performance.

Thus, a cable apparatus for minimizing skew delay of analog signals and cross-talk from digital signals, and method of making same, have been described. Particular embodiments described herein are illustrative only and should not limit the present invention thereby. The invention is defined by the claims and their full scope of equivalents.